1995event

SEA TURTLE STRANDINGS IN THE MIDDLE ATLANTIC

MAY-JULY 1995

Between late May and middle July, 1995, sea turtle strandings on the beaches of the southern Middle Atlantic Bight exceeded the historical average for this area and time. The timing of this event was coincident with the migration of turtles northward into the Middle Atlantic Bight and into inshore waters (Shoop and Kenney, 1992; Epperly et al., 1995).

Strandings off northern North Carolina first exceeded 75% of Indicated Take Level (ITL, defined by the South Atlantic Sea Turtle/Shrimp Fishery Emergency Response Plan) during week 21 (May 21-27) and continued to exceed the weekly ITL through week 28 (July 9-15) (Table 1). This event was not confined to North Carolina. (ITLs were calculated only for the NMFS Southeast Region's area.) Concurrently, strandings were occurring northward to the Cape Charles area, including inside the mouth of the Chesapeake Bay (Figure 1). By week 26 (June 25-July 1), strandings were occurring also on Maryland and Delaware beaches. From week 21 through week 28, 245 turtles (217 loggerhead, 15 leatherback, 8 Kemp's ridley, 3 green, and 2 unknown species) stranded between Portsmouth Island, N.C. and the southwestern shore of Delaware Bay (STSSN Zones 35 through Delaware Zone 39).

There appeared to be three concentrations of stranded animals. The first concentration centered around Cape Hatteras (southern

Zone 35). Generally, these animals were fresh dead or moderately decomposed. The second centered around Cape Charles (Zone 37). These animals mostly were severely decomposed. The largest concentration occurred in a third area, from Pea Island, N.C. northward to the Cape Henry area (Zone 36 and northern Zone 35). In this third area, carcasses to the north mostly were moderately decomposed (Tables 2-6); to the south, the animals mostly were severely decomposed. The causes of death could not be determined. A number of carcasses with prop wounds were noted. Only one turtle, a severely decomposed loggerhead that stranded near Cape Hatteras on June 7, was necropsied. This animal had evidence of food materials throughout its esophagus, stomach, and intestinal tract, indicating it had been feeding just prior to its death.

FISHING ACTIVITIES IN AREA

Very little shrimp trawling occurred north of Cape Lookout during the period of strandings, and then, not until a couple weeks after the strandings began (not before June 6) (Jeff Radonski, NMFS Special Agent, personal communication, June 7; Manley Gaskill, N.C. Division of Marine Fisheries Technician, personal communication, June 6; Glenn Montgomery, NMFS Fishery Reporting Specialist, personal communication, June 7). Radonski identified two shrimp trawlers in Ocracoke and Hatteras on June 20. One was equipped with a hard TED and the other was equipped with a soft TED. Shrimp trawling does not occur north of Cape Hatteras. Fly netting ended

about mid May, according to Radonski's report of June 19. Trawling for summer flounder probably had moved to outer shelf areas north of Cape Charles.

Purse seines, set for Atlantic menhaden, were used mostly inside Chesapeake Bay during May (80%), but a nominal number of sets were made at the mouth of the Bay (2%), off Virginia Beach (6%), and in Raleigh Bay (4%) (Captain's Daily Fishing Reports, Joseph Smith, NMFS Research Fishery Biologist, personal communication, September 15). A few sets (7%) were made off New Jersey and New York. In June, most purse seine activity was inside Chesapeake Bay (32%), with a substantial amount of sets made also off the Virginia eastern shore (25%), New Jersey (22%), and Virginia Beach (10%). A few sets were made off New York (2%), and Rhode Island (1%), also. During July, most sets were made inside Chesapeake Bay (39%), with activity occurring also off New Jersey and northward (41%), and off Virginia Beach (9%). Purse seine activity was greatest during June.

During early June, sink net boats (small mesh gill nets set for sciaenids) were still operating nearshore from Hatteras Bight northward (Doug Sawyer, N.C. Marine Patrol Officer, personal communication to Brian Zane, June 7). In the Cape Hatteras area, large mesh (9 1/2 monofilament to 13 1/2 inch twine stretch mesh) gill nets were set for large coastal sharks, beginning late May

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(Bill Foster, N.C. Marine Fisheries Commission Vice-Chairman, personal communication, July 18; Jim Francesconi, N.C. Division of Marine Fisheries Marine Biologist, personal communication, September 13). The nets were set overnight, sometimes soaking for >24 hr. Three fishermen were known to be involved. On June 10, the Hatteras Island Rescue Squad was alerted that a turtle was entangled in one of these nets just south of Cape Hatteras Point (Lou Browning, Hatteras Island Rescue Squad, personal communication, June 13). They responded and released the turtle alive. While they were untangling the first, a second struck the same net and was released, also. Both were large loggerheads. The fishermen quit setting these nets about the second week of July.

Traditionally a large mesh (12-13 inch) gill net fishery for black drum occurs during late April through June around Cape Charles (Dr. Jack Musick, Virginia Institute of Marine Sciences, personal communication, July 18; Dr. John Keinath, VIMS, personal communication, June 8; Greg Houghaboom, NMFS Special Agent, personal communication, September 29). In past years, this fishery has been responsible for a number of strandings during late spring on the eastern shore (Dr. John Keinath, Ibid.; Dr. Jack Musick, Ibid.; Greg Houghaboom, personal communication, June 7, September 29). Take is reportedly high (12 turtles involved or killed by one fisherman in a week near Machipungo Inlet). Presumably this fishery was operating spring 1995. Historically the fishery

operated at depths <40 ft, from Oyster, Va. to Cape Charles, and inside the mouth of the Bay. The nets were anchored on each end and are set sunset to sunrise.

Numerous gill nets of unknown mesh size were set around Cape Henry and southward along the Virginia beaches during the late May and early June, and perhaps later (Sean Bourgeois, Virginia Marine Sciene Museum, personal communicaton, June 7). The winter fishery for dogfish sharks [gill nets, about 7 inch mesh monofilament, set in cold water (<56°C)], had ended prior to the stranding event.

A pound net was set in Hatteras Bight (Bill Foster, Ibid.). The lead of the net was "stringer" mesh, documented to take turtles in the Chesapeake Bay (Bellmund et al., 1987). It was destroyed by storm surge before mid July. A few beach seine operations were fishing on the northern beaches during early June and longline activity was occurring offshore (>20 fm) (Doug Sawyer, Ibid.; Nelson Johnson, NMFS Fishery Reporting Specialist, personal communication, June 7; Glenn Montgomery, Ibid.). Trolling for tuna occurred offshore (Brian Zane, U.S. Coast Guard Group Cape Hatteras Operations Officer, personal communication, June 7; Greg Houghaboom, Ibid.).

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PHYSICAL OCEANOGRAPHY

By mid May, the western wall of the Gulf Stream was very close to Cape Hatteras (Advanced Very High Resolution Radiometer (AVHRR) Sea Surface Temperature (SST) imagery and Geostationary Satellite (GOES) imagery) (Figure 2). Water temperatures just beyond the surf at Cape Hatteras were >20°C (Sea Surface Thermal Analysis, 16 May). Nearshore waters north of Oregon Inlet, and along the Virginia eastern shore were approximately 15°C. A Gulf Stream filament extended over the shelf between Oregon Inlet and the mouth of Chesapeake Bay on May 24; waters near the mouth of the Bay had warmed slightly. Little remained of this excusion over the shelf by the end of the month. Nearshore waters at the mouth of the Chesapeake Bay and northward along the Peninsula warmed to >20°C by June 6. Gulf Stream frontal activity continued throughout the period, infrequently influencing the shelf area north of Cape Hatteras.

The U.S. Army Corps of Engineers (ACOE) has a Coastal Engineering Research Center Field Research Facility (FRF) at Duck, N.C. The FRF collects data on the local bathymetric, oceanographic, and meterological conditions, reflective of the nearshore area near Duck (Duck is located on the N.C. Outer Banks, near the N.C./Virginia border). They disseminate monthly reports (Figures 3-5). Compared to years 1993 and 1994, May-July 1995 was

somewhat anamolous. Currents during late May 1993-95 were southerly flowing and longshore; however, during 1995 the speeds were diminished as were wind speeds. Winds throughout June 1993 and 1994 mostly had a southerly component (from the south), but winds throughout June 1995 were quite variable, with most days showing winds from the north. Current direction during June 1995 was toward the south, alongshore, but speeds were diminished over speeds of 1993 and 1994. Winds during early July 1995 were from the southeast whereas winds during July 1993 and 1994 were predominately from the south and southwest. Current directions were similar (southerly), but again, speeds were diminished relative to past years. Wind data are available from the National Weather Service Office in Buxton, N.C., also.

CONCLUSIONS

The beginning of the stranding event (Week 21) may have coincided with the movement of turtles out of the South Atlantic Bight into the Middle Atlantic Bight, although we would have expected turtles to have moved northward before late May. More importantly, the timing probably coincided with the movement of turtles from offshore to inshore waters in the Middle Atlantic Bight, increasing the likelihood that a dead turtle stranded and exposing turtles to nearshore and inshore fisheries. For the majority of animals, there were no external indication of cause of

death. None were necropsied to determine if these deaths were natural causes. As with any animal population, natural mortality increases during stresses of migration.

Based on circumstantial evidence and historical patterns of strandings, there is reason to believe that the concentration of strandings in the Cape Charles area was related to the large mesh gill net fishery for black drum. Similarly, the concentration of strandings in the Cape Hatteras area probably was related to the large mesh gill net fishery for sharks, and possibly to the single pound net set just south of the Cape. There is no information on the source of strandings between Pea Island, N.C. and the Cape Henry, Va. area. Based on the pattern of carcass' condition (moderately decomposed to the north and severely composed to the south), one might surmise that the source of mortality was in the northern portion of this area, and that carcasses were transported southward. Gill nets were being set in the vicinity of Cape Henry and along Virginia Beach at the time of the strandings, but there is no evidence that there was any incidental take.

RECOMMENDATIONS

1. Address the impact of gill nets on sea turtle populations, especially that of large mesh gill nets. Two large mesh gill net

fisheries were implicated in this mid Atlantic stranding event, one in North Carolina and one in Virginia:

> The North Carolina Marine Fisheries Commission has received a proposal to ban all gill nets >7 inches in the N.C. territorial sea, except for nets set for striped bass. Public hearings will be held this fall on a suite of N.C. proposals, including this one. If passed, the regulation would take effect summer 1996. This regulation would eliminate the budding nearshore fishery for large coastal pelagic sharks. The fishery began anew during the week of September 17-23, and on September 27, 2 leatherback sea turtles were [lethal] taken in one of the nets set just south of Cape Hatteras. The NCDMF Director has the authority to close this fishery by proclamation, in advance of Commission rulemaking.

2. Determine what fisheries are active during May-July, between Cape Hatteras and Cape May, and determine the likelihood that they interact with sea turtles.

> The Virginia Marine Resources Commission and the NMFS Northeast Regional Office did not respond to requests for information on active fisheries in the area.

3. Identfy sources of physical oceanographic data for the area and time, and contract the analysis to determine wind and current

patterns affecting the fate of carcasses, thereby identifying the source area of mortalities.

Sheryan P. Epperly

September 30, 1995

Table 1. Strandings and Indicated Take Levels in the South Atlantic, by week.

ATLANTIC		*ZONE 30*			*ZONE 31*			ZONE 32		
Week	Week Period	ITL(OFF)	OFFSHORE	INSHORE	ITL(OFF)	OFFSHORE	INSHORE	ITL(OFF)	OFFSHORE	INSHORE
1-13	1st Quarter	NA	3(1)	1	NA	1	0	NA	0	0
14-20	4/ 2 - 5/20	NA	31(6)	1	NA	9(3)	0	NA	7	3
21	5/21 - 5/27	11	6(1)	0	8	4(1)	0	8	4	0
22	5/28 - 6/ 3	11	7	0	8	16(1)	2	8	12(1)	2
23	6/ 4 - 6/10	9	6(1)	3(1)	7	23(4)	4(3)	9	6	1
24	6/11 - 6/17	8	25(6)	3	6	5(1)	3(1)	8	11	1
25	6/18 - 6/24	7	13	0	6	6(2)	1	7	1	2
26	6/25 - 7/ 1	6	2	1(1)	6	1	0	6	3	0
27	7/ 2 - 7/ 8	7	5(1)	0	5	3	0	5	3	0
28	7/ 9 - 7/15	8	8(1)	0	6	4(1)	1	4	8(2)	1
29	7/16 - 7/22	7	5(2)	0	5	6(2)	1	4	4	0
30	7/23 - 7/29	8	5		5	4(1)	4	4	4	
31	7/30 - 8/ 5	9			4			3		
32	8/ 6 - 8/12	7			4			3		

SOUTHEAST ATLANTIC		ZONE 33			ZONE 34			ZONE 35		
Week	Week Period	ITL(OFF)	OFFSHORE	INSHORE	ITL(OFF)	OFFSHORE	INSHORE	ITL(OFF)	OFFSHORE	INSHORE
1-13	1st Quarter	NA	1	0	NA	5	1	NA	6(1)	2
14-20	4/ 2 - 5/20	NA	13	3	NA	19	2	NA	8	0
21	5/21 - 5/27	4	7(1)	0	5	3	2	4	15	0
22	5/28 - 6/ 3	4	3	0	5	6	1	4	30	2
23	6/ 4 - 6/10	4	1	0	7	4	0	5	12	0
24	6/11 - 6/17	4	4	4	7	1	1	5	6	0
25	6/18 - 6/24	5	2	0	6	0	0	3	7	1
26	6/25 - 7/ 1	6	5	1	6	1	1	2	10	0
27	7/ 2 - 7/ 8	7	4(1)	2	6	4	2	2	2	0
28	7/ 9 - 7/15	9	7	4	4	1	3	2	1	0
29	7/16 - 7/22	9	3	1	4	1	1	2	0	0
30	7/23 - 7/29	8			3			2		
31	7/30 - 8/ 5	7			2			2		
32	8/ 6 - 8/12	5			2			2		

SOUTHEAST ATLANTIC		ZONE 36		
Week	Week Period	ITL(OFF)	OFFSHORE	INSHORE
1-13	1st Quarter	NA	0	0
14-20	4/ 2 - 5/20	NA	1	0
21	5/21 - 5/27	2	1	0
22	5/28 - 6/ 3	2	6	0
23	6/ 4 - 6/10	2	5	0
24	6/11 - 6/17	2	8	1
25	6/18 - 6/24	2	2	0
26	6/25 - 7/ 1	2	7	0
27	7/ 2 - 7/ 8	2	3	0
28	7/ 9 - 7/15	2	2	0
29	7/16 - 7/22	2	0/1	0
30	7/23 - 7/29	2		
31	7/30 - 8/ 5	2		
32	8/ 6 - 8/12	2		

Tables 2-5. Sea turtle strandings, by week, species and condition, in Statistical Zones 35-39.

STSSN ZONE 35

		SPECIES					
		loggerhead	green	leatherback	Kemp"s ridley	unknown	
		number	number	number	number	number	ALL
		N	N	N	N	N	N
WEEK	condition						
20	fresh dead	1.00	.	.	.	.	1.00
	severely decomposed	.	.	1.00	.	.	1.00
21	moderately decomposed	1.00	.	.	.	.	1.00
	severely decomposed	14.00	.	.	.	.	14.00
22	fresh dead	7.00	.	.	1.00	.	8.00
	moderately decomposed	9.00	.	1.00	.	.	10.00
	severely decomposed	14.00	.	1.00	.	.	15.00
23	alive	2.00	.	.	.	.	2.00
	fresh dead	2.00	.	.	.	.	2.00
	moderately decomposed	4.00	.	.	.	.	4.00
	severely decomposed	3.00	1.00	.	1.00	1.00	6.00
24	fresh dead	2.00	.	.	.	.	2.00
	moderately decomposed	1.00	.	.	.	.	1.00
	severely decomposed	2.00	.	1.00	.	.	3.00
25	fresh dead	1.00	.	.	.	.	1.00
	moderately decomposed	4.00	.	.	.	.	4.00

(CONTINUED)

STSSN ZONE 35

		SPECIES					
		loggerhead	green	leatherback	Kemp"s ridley	unknown	
		number	number	number	number	number	ALL
		N	N	N	N	N	N
WEEK	condition						
25	severely decomposed	3.00	.	.	.	.	3.00
26	fresh dead	2.00	.	.	.	.	2.00
	moderately decomposed	1.00	.	.	.	.	1.00
	severely decomposed	7.00	.	.	.	.	7.00
27	fresh dead	1.00	.	.	.	.	1.00
	moderately decomposed	1.00	.	.	.	.	1.00
28	moderately decomposed	.	.	1.00	.	.	1.00
29	fresh dead	3.00	.	.	.	.	3.00
30	fresh dead	1.00	.	.	.	.	1.00
	severely decomposed	1.00	.	.	.	.	1.00
ALL		87.00	1.00	5.00	2.00	1.00	96.00

STSSN ZONE 36

		SPECIES					
		loggerhead	green	leatherback	Kemp"s ridley	unknown	ALL
		number	number	number	number	number	
		N	N	N	N	N	N
WEEK	condition						
20	fresh dead	1.00	.	.	.	.	1.00
	moderately decomposed	1.00	.	.	.	.	1.00
21	moderately decomposed	1.00	.	.	1.00	.	2.00
	severely decomposed	1.00	.	.	.	.	1.00
22	fresh dead	2.00	.	.	.	.	2.00
	moderately decomposed	3.00	.	.	1.00	.	4.00
	severely decomposed	8.00	.	.	.	.	8.00
23	fresh dead	2.00	.	.	.	.	2.00
	moderately decomposed	8.00	.	.	.	.	8.00
	severely decomposed	7.00	.	.	.	.	7.00
24	fresh dead	1.00	.	.	.	.	1.00
	moderately decomposed	7.00	.	.	.	.	7.00
	severely decomposed	7.00	.	1.00	.	1.00	9.00
25	fresh dead	1.00	.	.	.	.	1.00
	moderately decomposed	3.00	1.00	.	.	.	4.00

(CONTINUED)

SESSN ZONE 36

		SPECIES					
		loggerhead	green	leatherback	Kemp"s ridley	unknown	
		number	number	number	number	number	ALL
		N	N	N	N	N	N
WEEK	condition						
25	severely decomposed	3.00	.	.	.	.	3.00
26	fresh dead	2.00	.	.	.	.	2.00
	moderately decomposed	6.00	.	.	.	.	6.00
	severely decomposed	7.00	.	.	.	.	7.00
27	moderately decomposed	1.00	.	2.00	.	.	3.00
	severely decomposed	.	.	1.00	.	.	1.00
28	moderately decomposed	2.00	.	.	.	.	2.00
	severely decomposed	1.00	.	.	.	.	1.00
29	severely decomposed	1.00	.	.	.	1.00	2.00
31	severely decomposed	1.00	.	.	.	.	1.00
32	moderately decomposed	1.00	.	.	.	.	1.00
	severely decomposed	.	.	1.00	.	.	1.00
ALL		78.00	1.00	5.00	2.00	2.00	88.00

SESSN ZONE 37

		SPECIES					
		loggerhead	green	leatherback	Kemp"s ridley	unknown	ALL
		number	number	number	number	number	
		N	N	N	N	N	N
WEEK	condition						
20	moderately decomposed	1.00	.	.	.	.	1.00
	severely decomposed	1.00	.	.	.	1.00	2.00
21	alive	1.00	.	.	.	.	1.00
	moderately decomposed	2.00	.	.	1.00	.	3.00
	severely decomposed	6.00	.	.	.	.	6.00
22	moderately decomposed	5.00	.	.	2.00	.	7.00
	severely decomposed	12.00	.	.	1.00	.	13.00
23	moderately decomposed	1.00	.	.	.	.	1.00
	severely decomposed	8.00	.	.	.	.	8.00
24	moderately decomposed	2.00	.	.	.	.	2.00
25	moderately decomposed	2.00	.	.	.	.	2.00
	severely decomposed	6.00	.	1.00	.	.	7.00
26	moderately decomposed	1.00	1.00	1.00	.	.	3.00
	severely decomposed	.	.	1.00	.	.	1.00

(CONTINUED)

STSSN ZONE 37

		SPECIES					
		loggerhead	green	leatherback	Kemp"s ridley	unknown	
		number	number	number	number	number	ALL
		N	N	N	N	N	N
WEEK	condition						
27	severely decomposed	1.00	.	.	.	.	1.00
30	severely decomposed	1.00	1.00	.	.	.	2.00
31	severely decomposed	1.00	.	.	.	.	1.00
ALL		51.00	2.00	3.00	4.00	1.00	61.00

STSSN ZONE 38

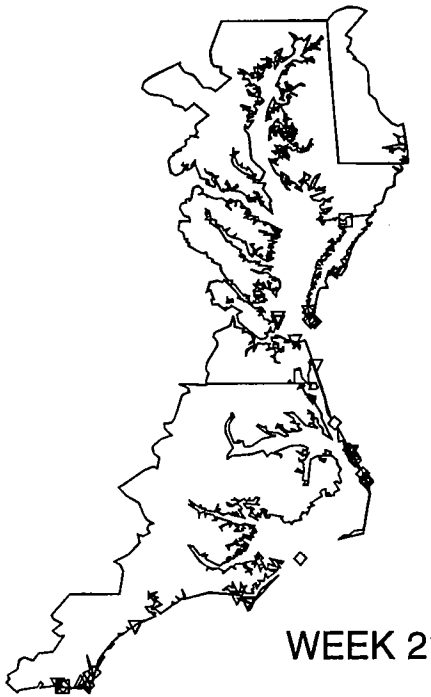
		SPECIES		
		loggerhead	leatherback	
		number	number	ALL
WEEK	condition	N	N	N
22	fresh dead	1.00	.	1.00
	severely decomposed	1.00	.	1.00
23	moderately decomposed	1.00	.	1.00
24	severely decomposed	1.00	.	1.00
25	moderately decomposed	1.00	.	1.00
	severely decomposed	1.00	1.00	2.00
26	moderately decomposed	3.00	1.00	4.00
	severely decomposed	1.00	1.00	2.00
27	moderately decomposed	1.00	.	1.00
	severely decomposed	3.00	1.00	4.00
29	moderately decomposed	.	1.00	1.00
30	moderately decomposed	1.00	1.00	2.00
	severely decomposed	.	1.00	1.00
ALL		15.00	7.00	22.00

STSSN ZONE 39

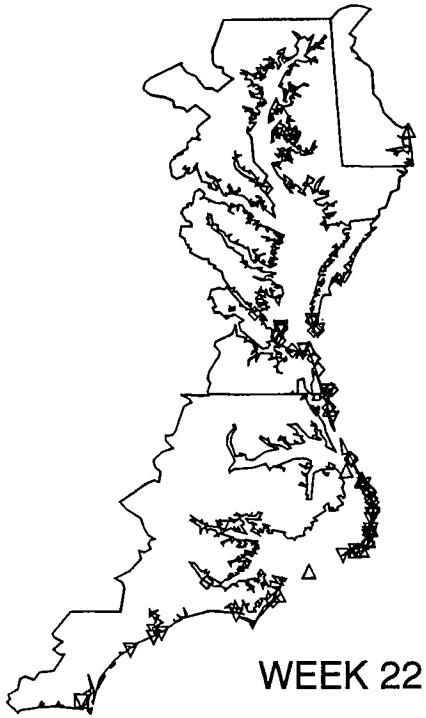
		SPECIES	
		loggerhead	
		number	ALL
		N	N
WEEK	condition		
24	severely decomposed	1.00	1.00
27	moderately decomposed	1.00	1.00
ALL		2.00	2.00

Figure 1. Sea turtles strandings in the southern Middle Atlantic Bight, by week, May 21-August 12, 1955. Symbols denote condition of carcass: square = alive, triangle = fresh dead, inverted triangle = moderately decomposed, and diamond = severely decomposed.

WEEK 20



WEEK 21



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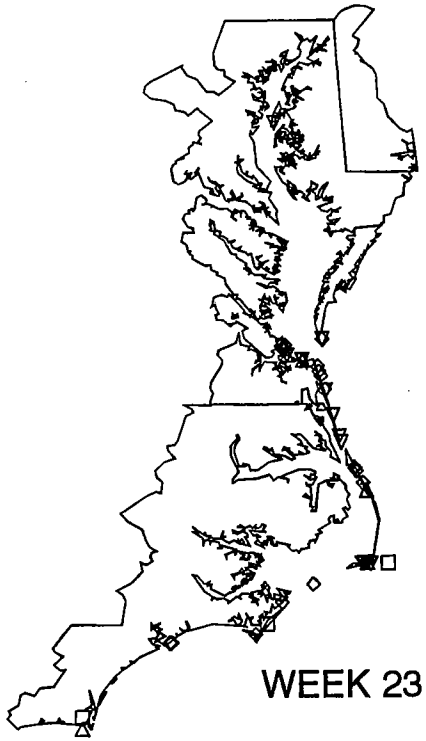

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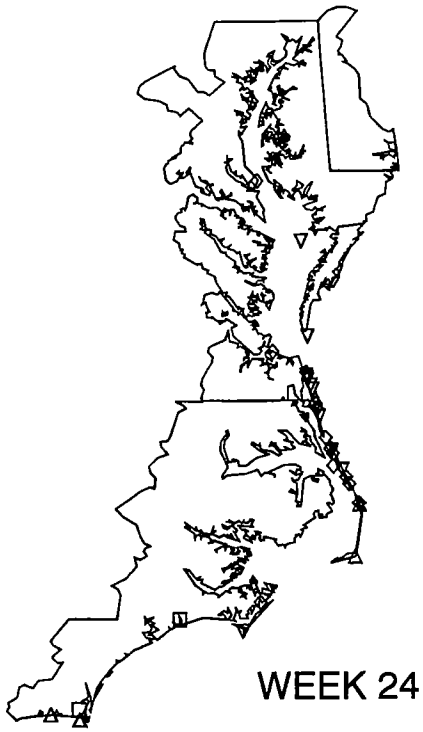
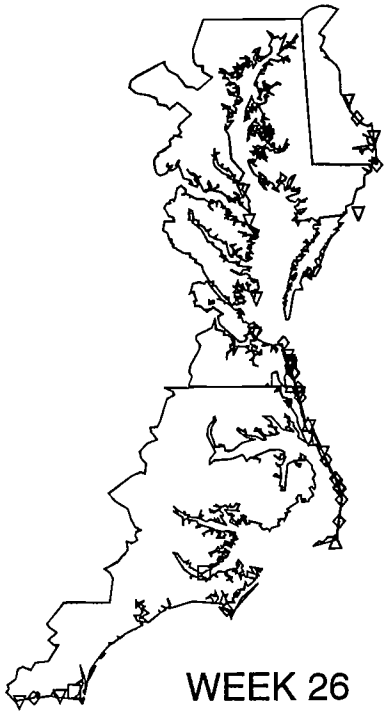


WEEK 24

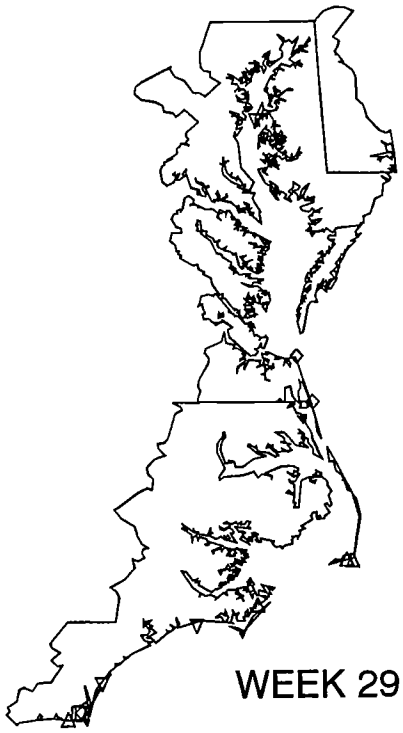
WEEK 25



WEEK 26

WEEK 27

WEEK 28



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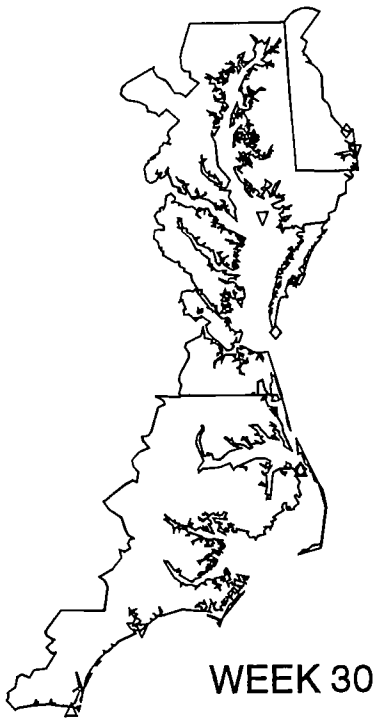
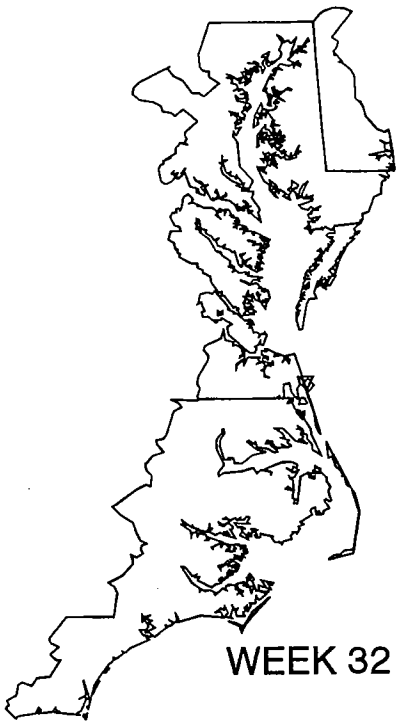


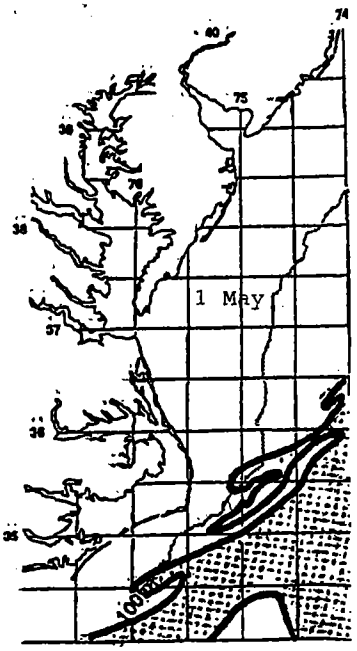
WEEK 30

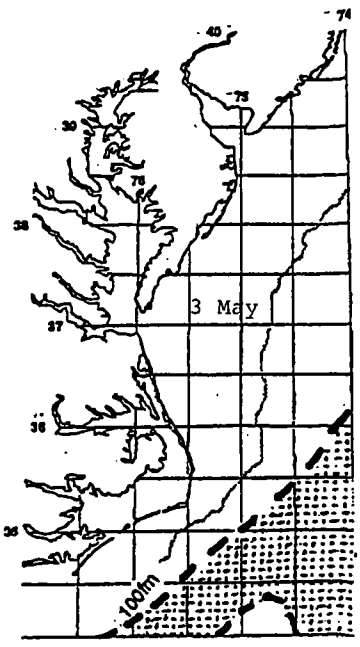
WEEK 31

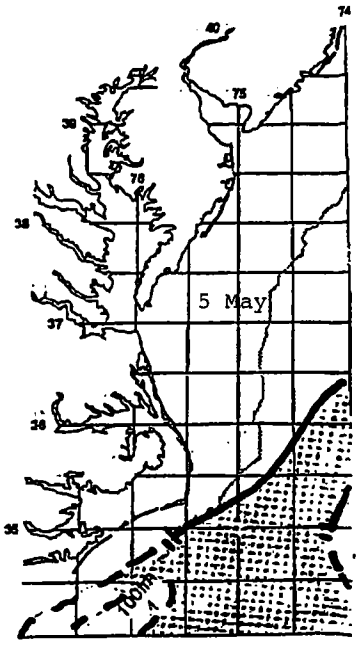


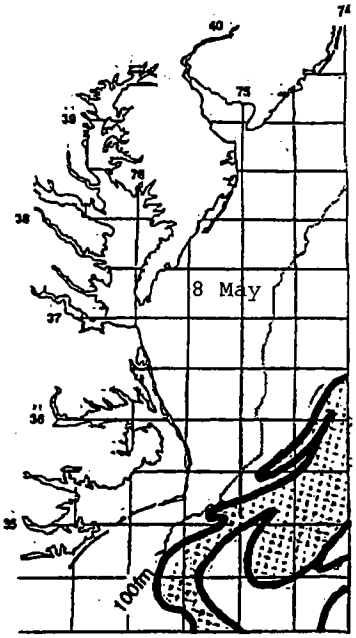
WEEK 32

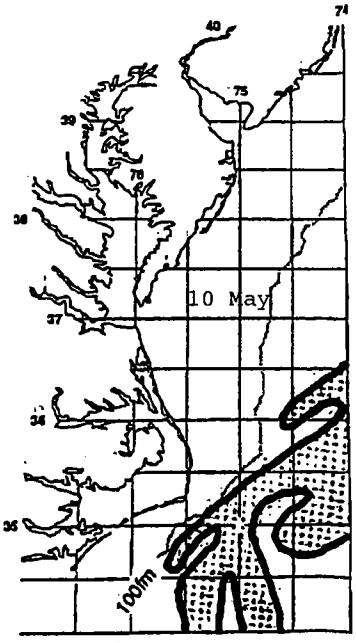
Figure 2. Gulf Stream System Flow Charts, May-August 1995. Information from NOAA, Miami SFSS.

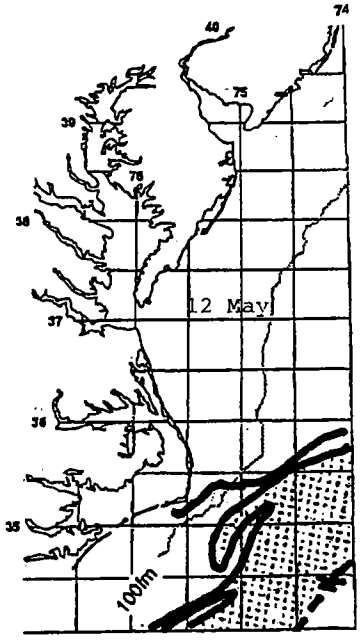

1 May
100fm

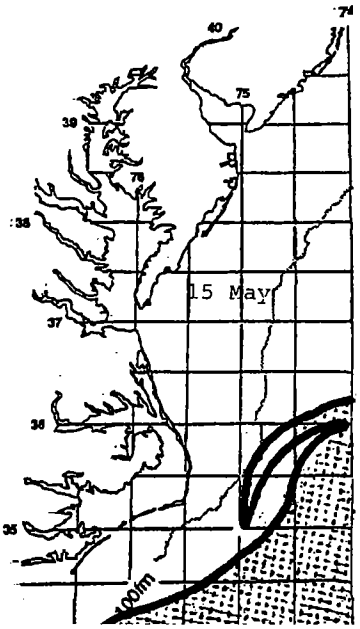

3 May
100fm

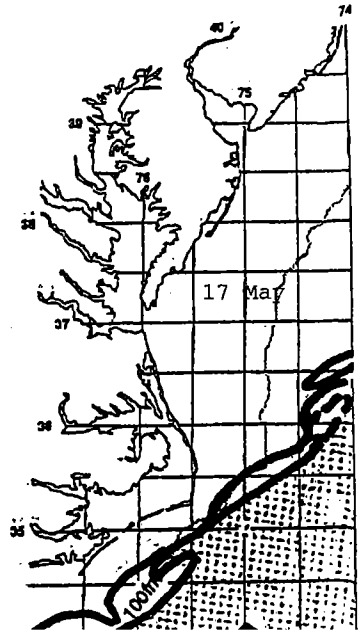

5 May
100fm

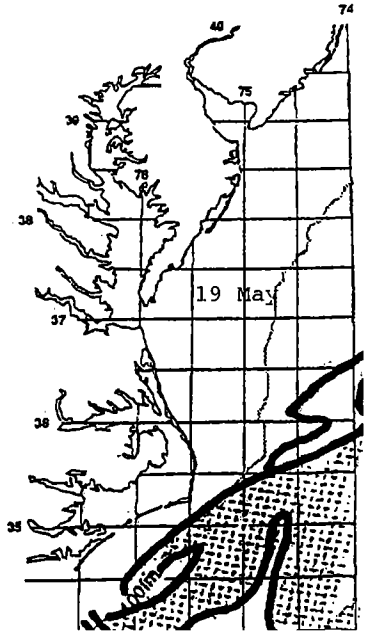

8 May
100fm

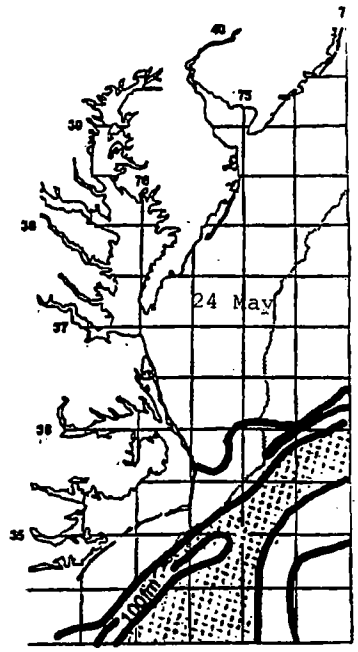

10 May
100fm

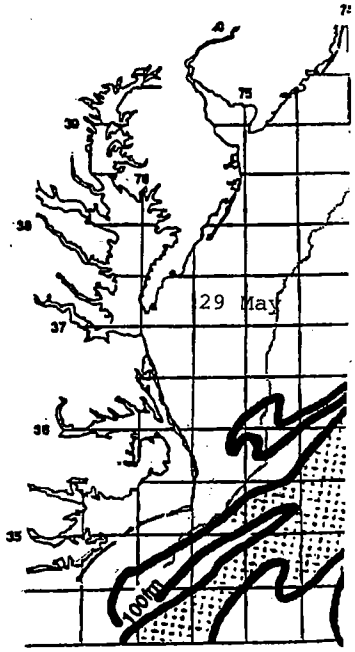

12 May
100fm

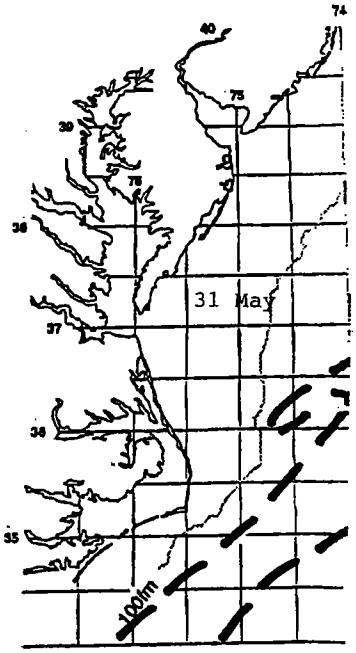

15 May
100fm

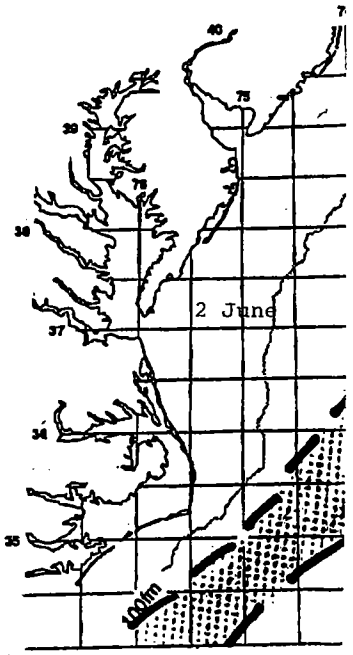

17 May
100fm

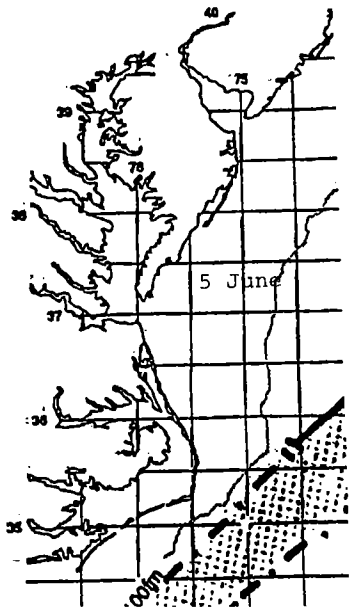

19 May
100fm

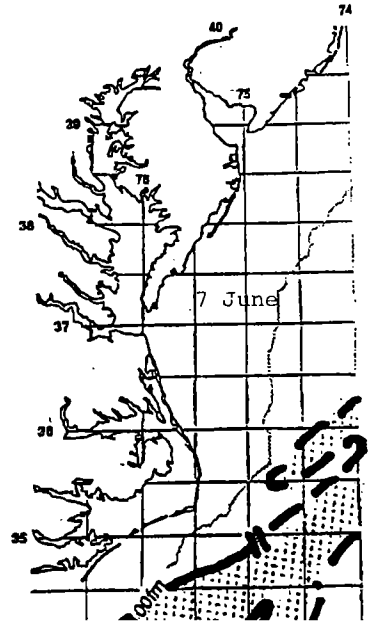

24 May
100fm

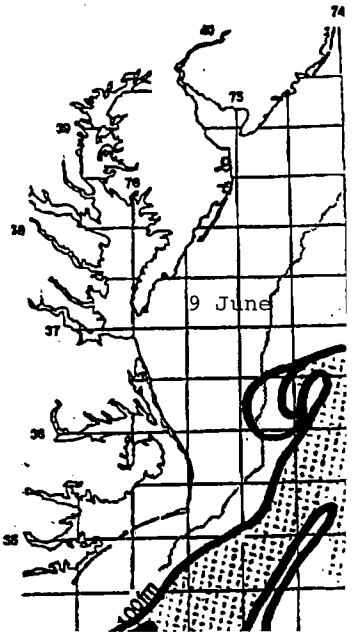

29 May
100fm

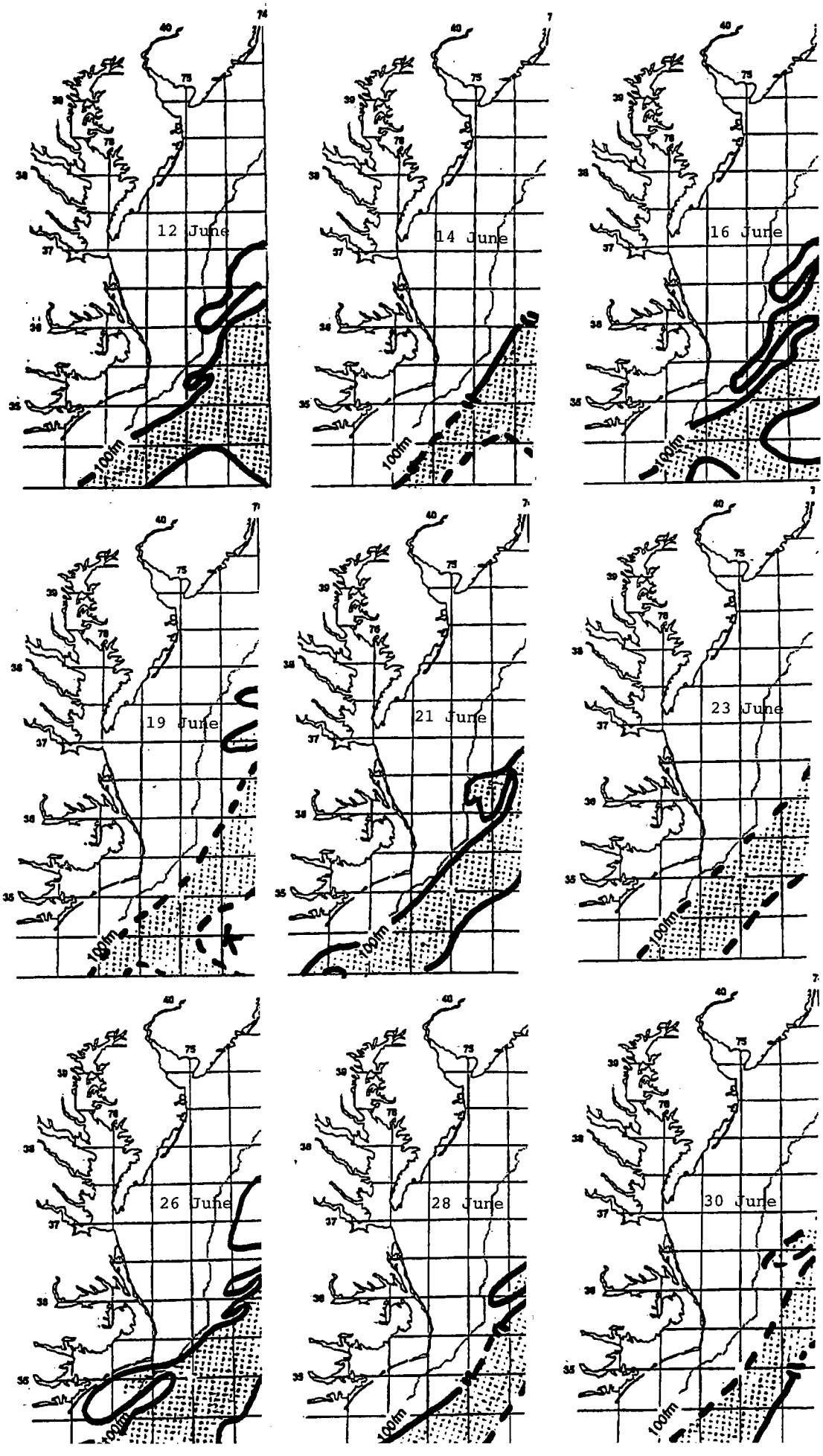

31 May
100fm

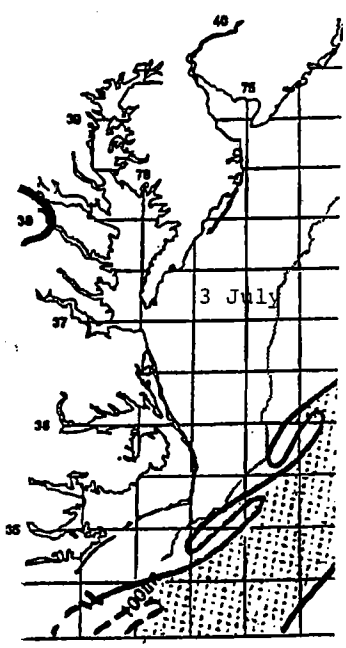

2 June
100fm

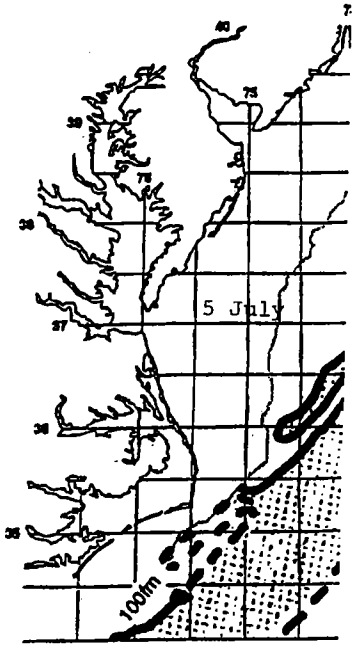

5 June
100fm

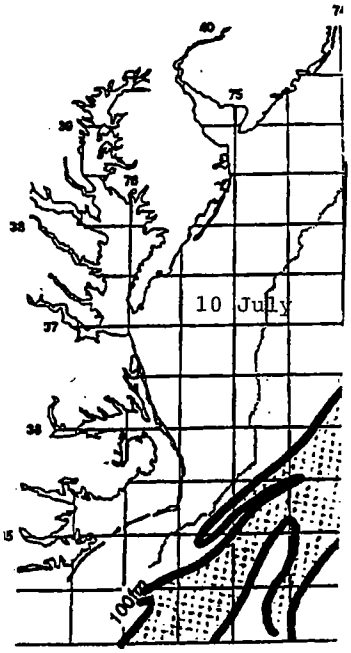

7 June
100fm

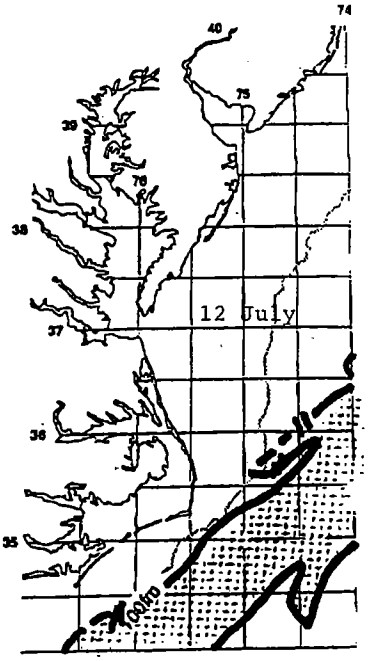

9 June
100fm

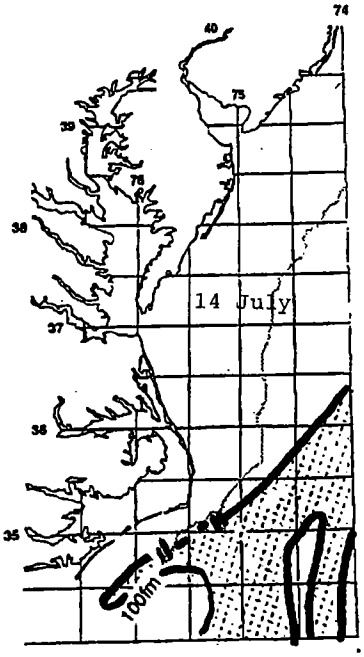

12 June
14 June
16 June
19 June
21 June
23 June
26 June
28 June
30 June
100fm

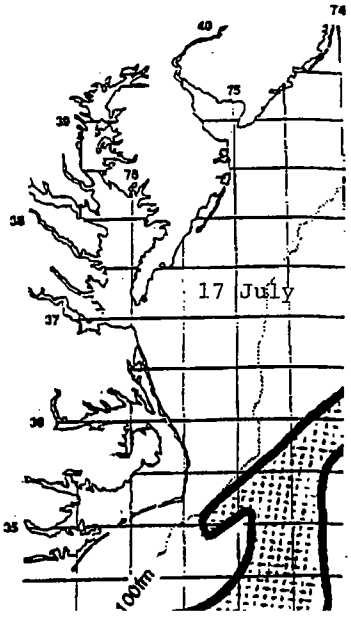

3 July
100fm

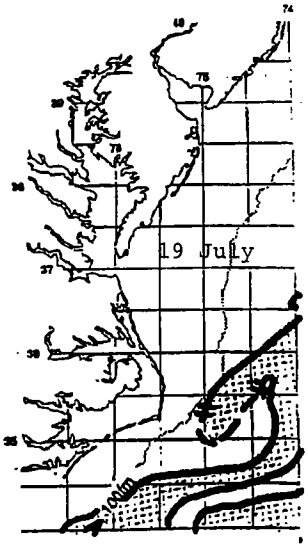

5 July
100fm

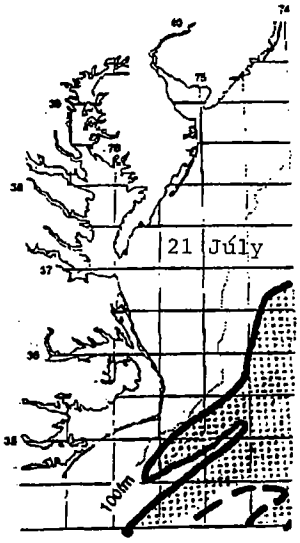

10 July
100fm


12 July
100fm

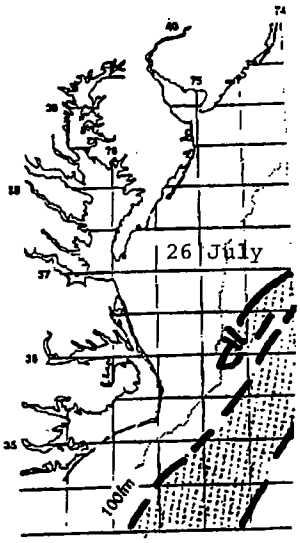

14 July
100fm

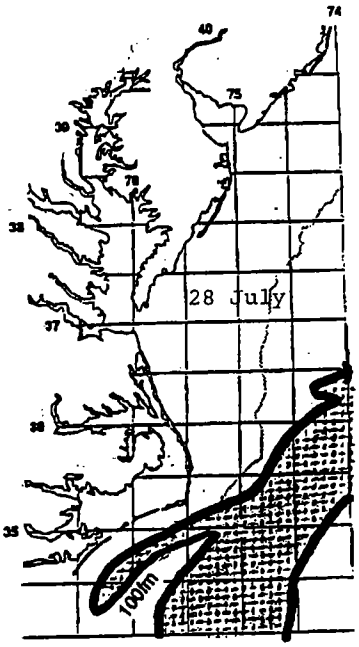

17 July
100fm

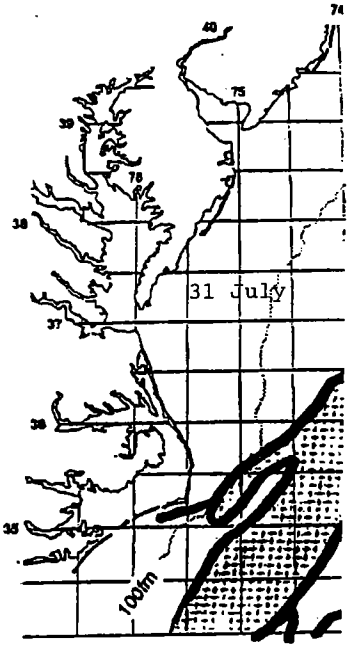

19 July
100fm

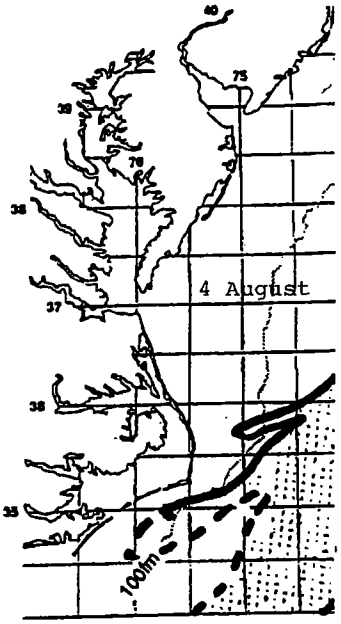

21 July
100fm

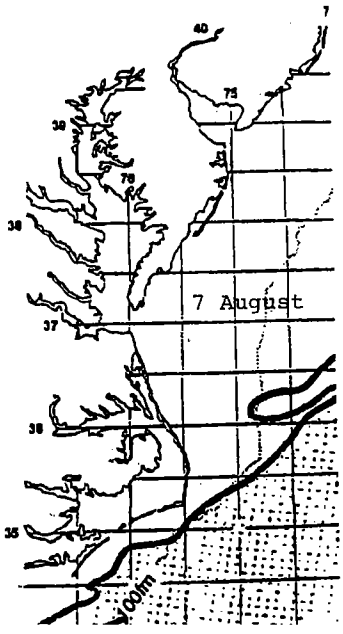

24 July
100fm

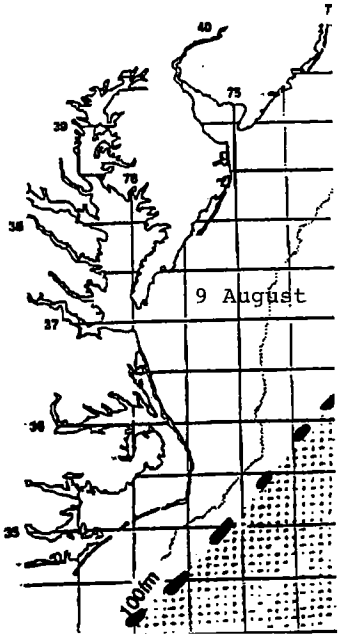

26 July
100fm

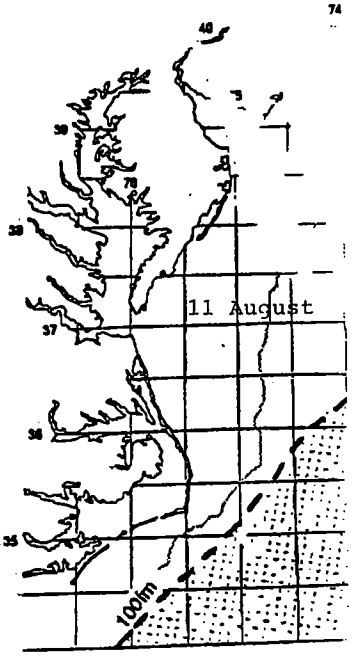

28 July
100fm

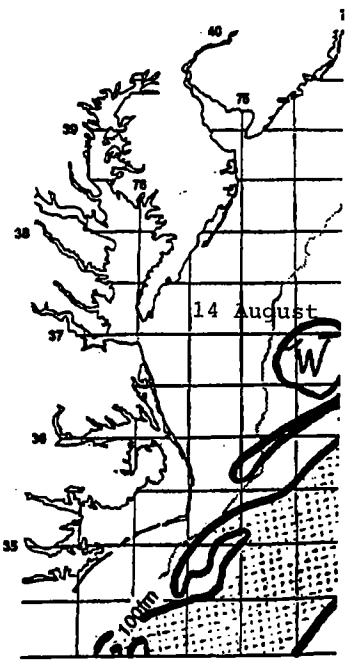

31 July
100fm

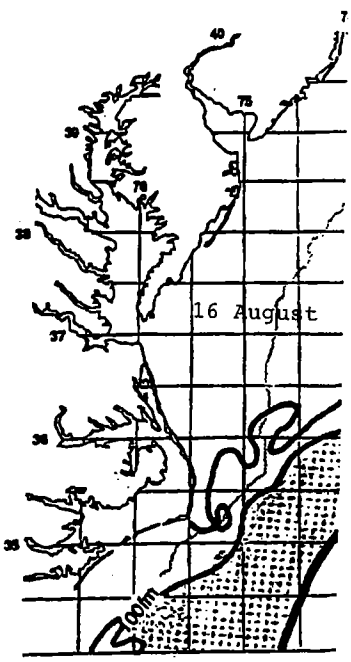

4 August
100fm

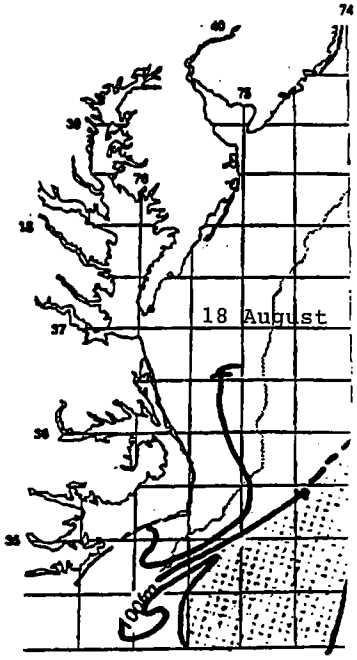

7 August
100fm

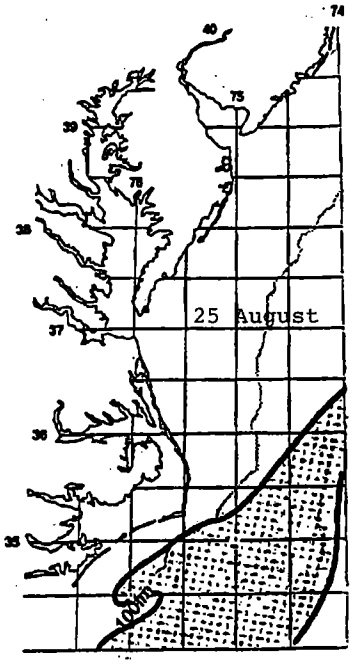

9 August
100fm


11 August
100fm









Depicted land should not be used for navigation.

Position lines are for the edges of warmer water.

——— Position based on data 0 to 2 days old.

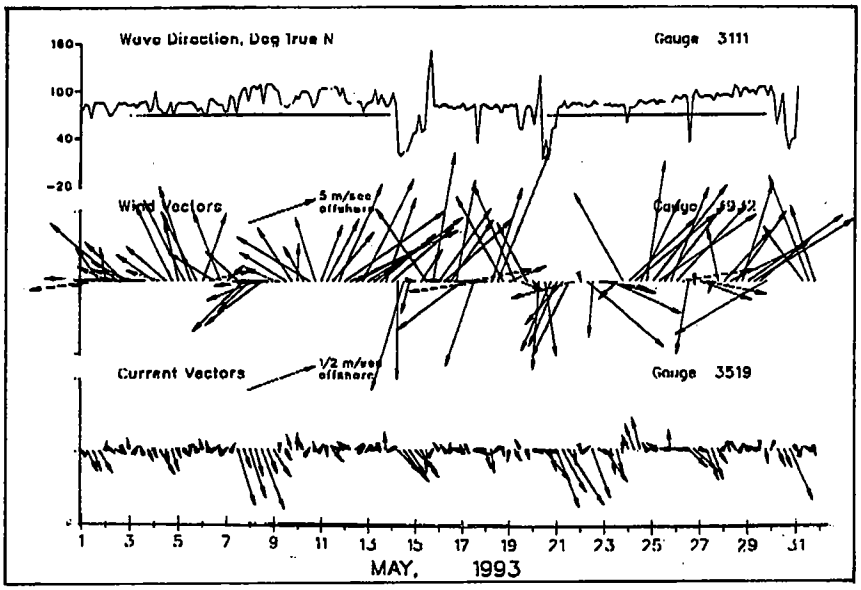
– – – – – Position based on data 3 to 7 days old.

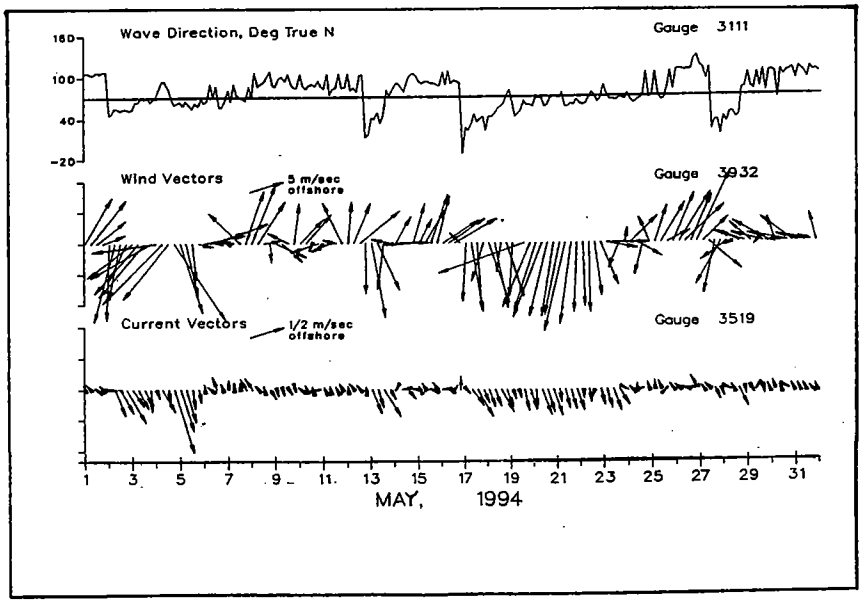
——— Position based on data 8 or more days old.

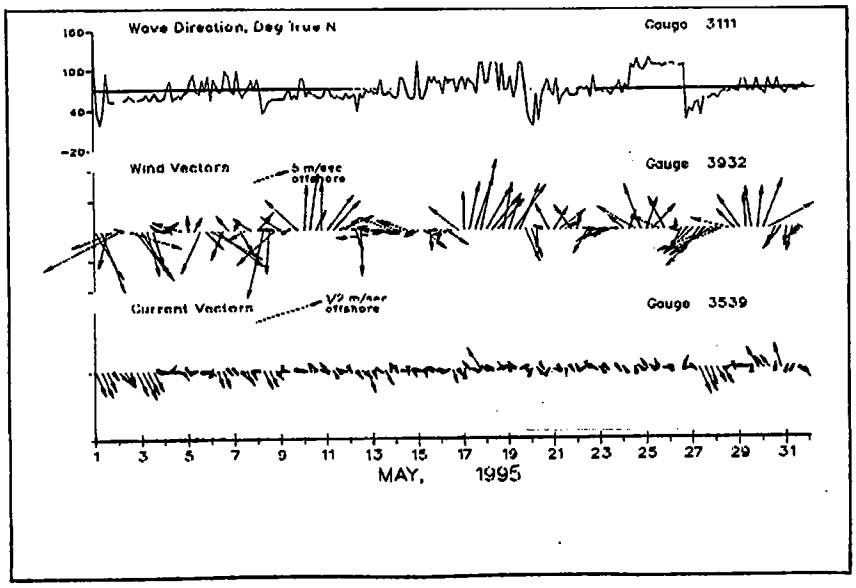
..... Mean position for month.

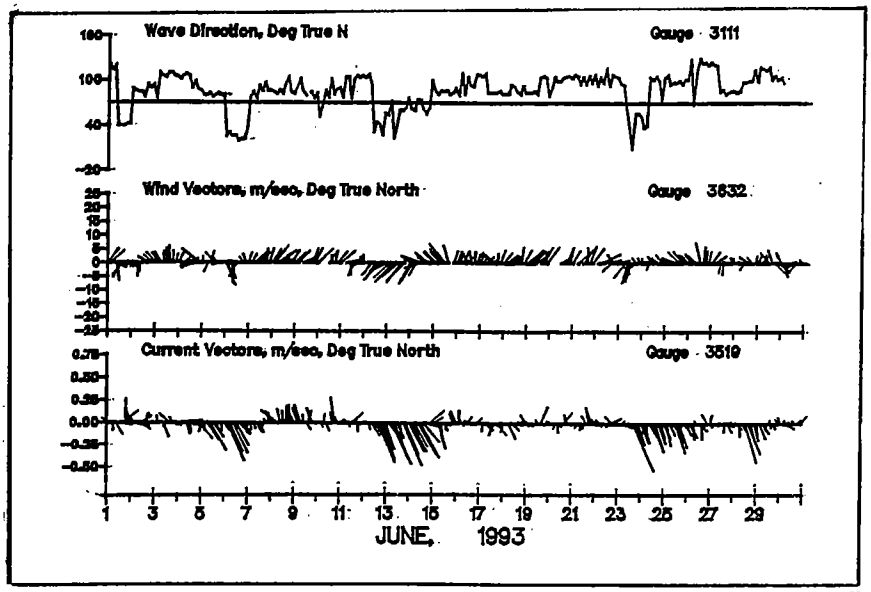
VK very cold
K cold
M mixed
W warm

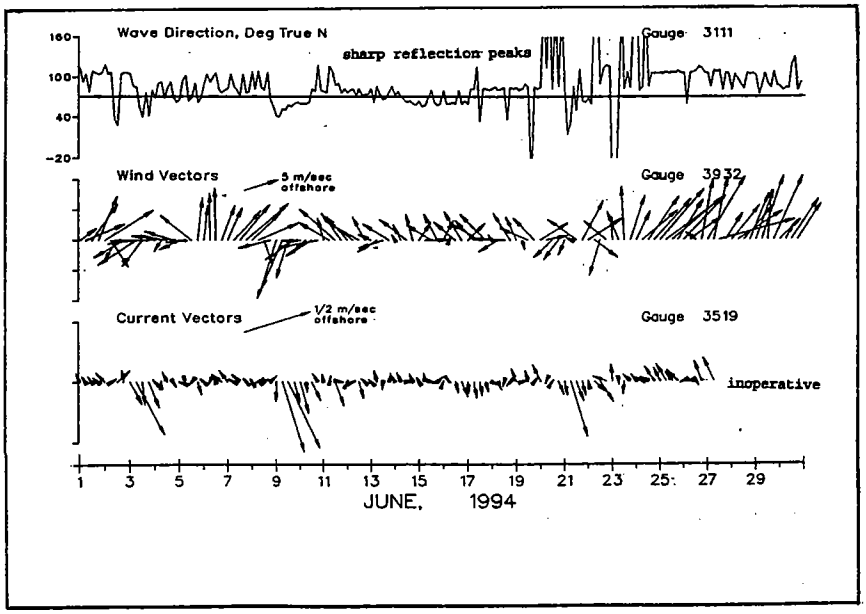
Figure 3. Month at a Glance, May-July, 1993-1995. Oceanographic data at Duck, N.C. From Preliminary Data Summaries of the Field Research Facility, Coastal Engineering Research Center, U.S. Army of Engineer Waterways Experiment Station.

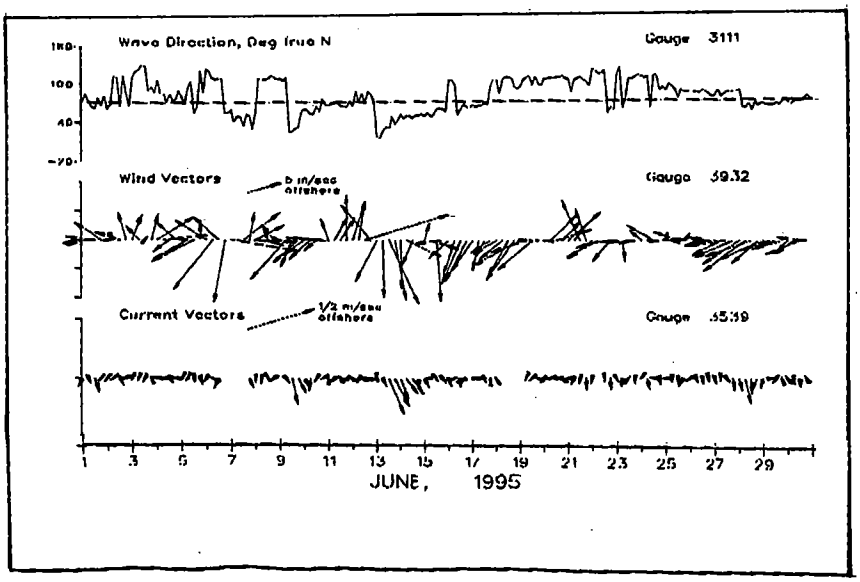

Wave Direction, Deg True N
Gauge 3111
160
100
40
-20
Wind Vectors
5 m/sec offshore
Gauge 3932
Current Vectors
1/2 m/sec offshore
Gauge 3519
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
MAY, 1993

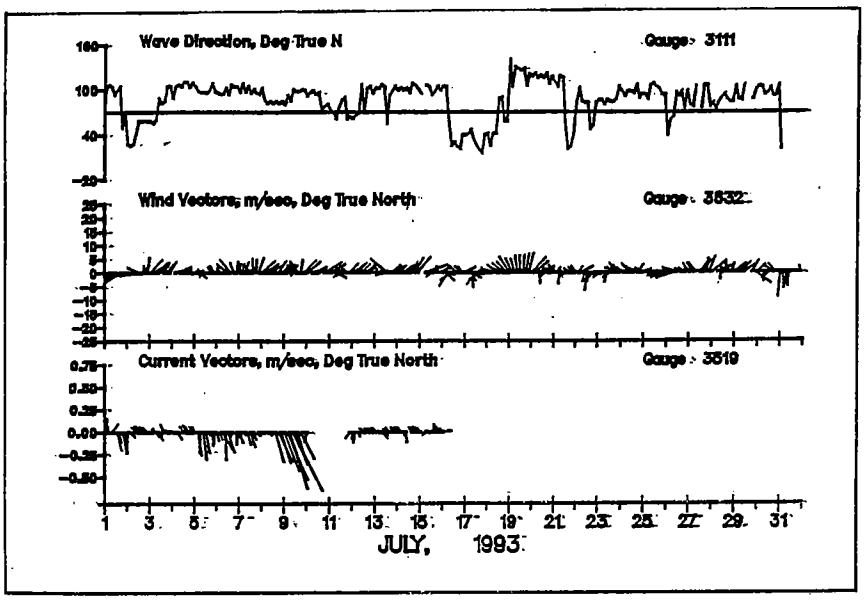

Wave Direction, Deg True N
Gauge 3111
160
100
40
-20
Wind Vectors
5 m/sec offshore
Gauge 3932
Current Vectors
1/2 m/sec offshore
Gauge 3519
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
MAY, 1994

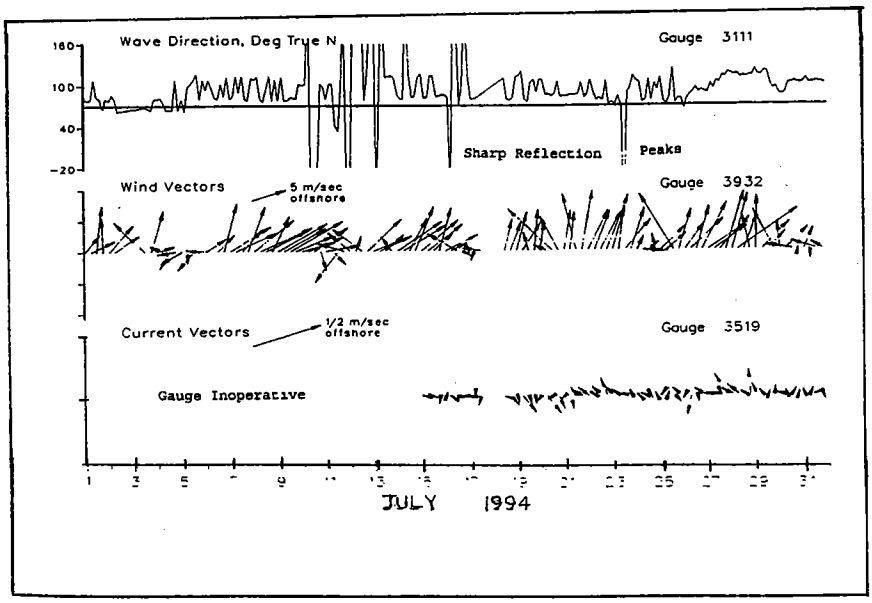

Wave Direction, Deg True N
Gauge 3111
160
100
40
-20
Wind Vectors
5 m/sec offshore
Gauge 3932
Current Vectors
1/2 m/sec offshore
Gauge 3539
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
MAY, 1995

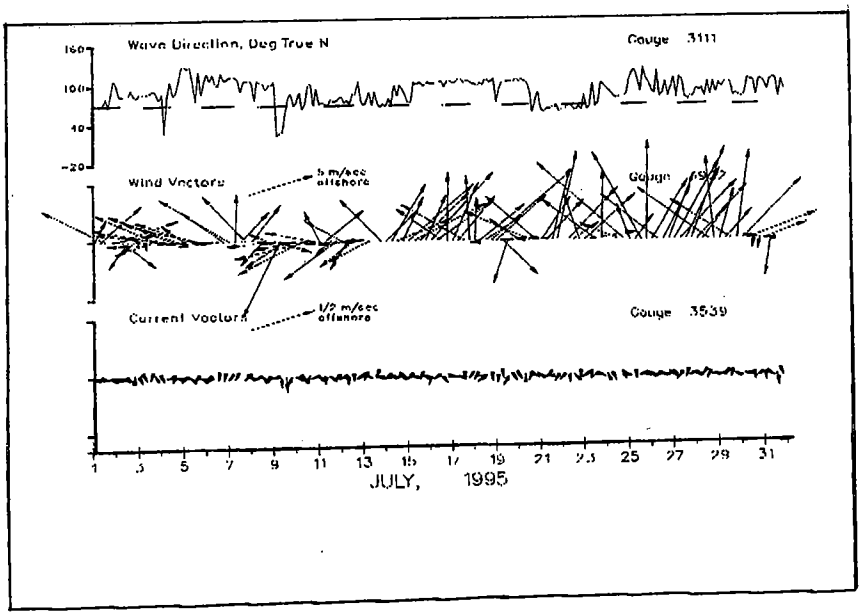

Wave Direction, Deg True N
Gauge 3111
Wind Vectors, m/sec, Deg True North
Gauge 3632
Current Vectors, m/sec, Deg True North
Gauge 3519
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
JUNE, 1993


Wave Direction, Deg True N
sharp reflection peaks
Gauge 3111
Wind Vectors
5 m/sec offshore
Gauge 3932
Current Vectors
1/2 m/sec offshore
Gauge 3519
inoperative
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
JUNE, 1994


Wave Direction, Deg True N
Gauge 3111
Wind Vectors
5 m/sec offshore
Gauge 3932
Current Vectors
1/2 m/sec offshore
Gauge 3519
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
JUNE, 1995


Wave Direction, Deg True N
Gauge 3111
Wind Vectors, m/sec, Deg True North
Gauge 3932
Current Vectors, m/sec, Deg True North
Gauge 3519
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
JULY, 1993


Wave Direction, Deg True N
Gauge 3111
Sharp Reflection
Peaks
Wind Vectors
5 m/sec offshore
Gauge 3932
Current Vectors
1/2 m/sec offshore
Gauge 3519
Gauge Inoperative
JULY 1994


Wave Direction, Deg True N
Gauge 3111
Wind Vectors
5 m/sec offshore
Current Vectors
1/2 m/sec offshore
Gauge 3539
JULY, 1995